Experimental and kinetic modeling study of biomass pyrolysis in an entrained flow reactor

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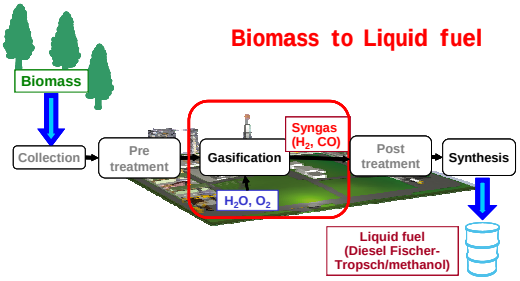
Motivation of the work:

Biomass to Liquid fuel



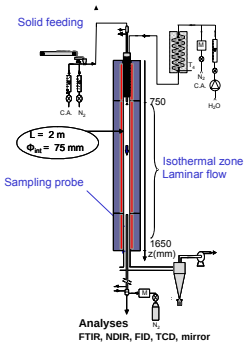
ABSTRACT

The general features of biomass pyrolysis are analysed both on the basis of a specifically conceived set of experiments and on the basis of a detailed kinetic analysis including successive gas phase reactions of released species. Experiments are performed in a lab-scale Entrained Flow Reactor (EFR) to investigate biomass pyrolysis under high temperatures (1073-1273 K) and fast heating rate conditions (>500 K/s).

The influence of the particle dimensions, of the temperature and of the residence time of gas and particles has been tested.

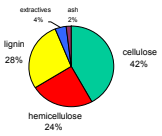
The particle size appeared as the most crucial parameter. Volatile components released by the solid particles are then involved in a detailed kinetic scheme of gas phase pyrolysis and combustion, in order to better understand their successive fate. In this way it is possible not only to explain the formation of CH_4 and C_2 species, but also to predict the successive formation of benzene and aromatic components

The entrained flow reactor

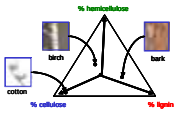


Biomass Composition and Model Assumptions

- Average biomass composition:



- Linear combination of cellulose, hemicellulose and lignin

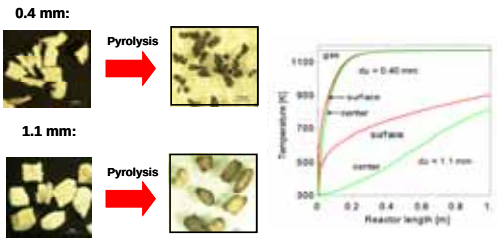


- Model input data (*):
  - Moisture
  - Cellulose,
  - Hemicellulose
  - Lignin
  - Ash

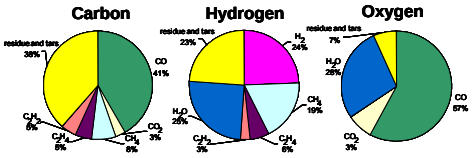
(*) When biochemical analysis is not available, Cellulose, hemicellulose and lignin content are derived from Elemental Analysis with simple correlations.

Influence of the particle size

Large particles are only toasted, while small particles are completely charified

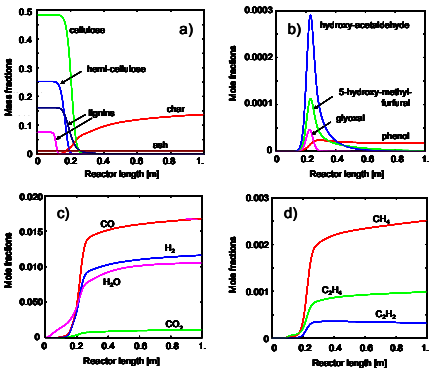


Experimental measurements



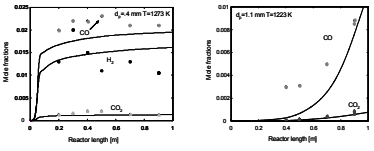
- **CO is the major species** (~ 50% of converted C is in CO)
- ~ 90% of O is in CO and H_2O
- Hydrogen is equally distributed between H_2, H_2O and CH_4+C_2 and tars
- **C_2H_4 et C_2H_2 are not negligible**

Model Predictions



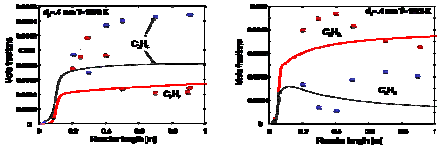
Model Predictions and Experiments

Effect of particle diameter.



Comparisons between experimental data (points) and model predictions (lines) at 1273 K for 0.4 mm and 1.1 mm particles

Temperature Effect on secondary species:
Ethylene and Acetylene yields



Lumped multi-step devolatilization reactions are assumed for cellulose, hemicellulose and lignins.
Stoichiometry of devolatilization reactions refer to lumped volatile components.
A linear additive rule is assumed for biomasses.

Secondary gas phase pyrolysis and oxidation reactions are included in a general detailed kinetic scheme of pyrolysis and combustion of large hydrocarbon fuels.

Gas-particle model include both intra and inter-phase resistances of heat and mass transfer.

Mass and Energy balances of Entrained Flow Reactor are solved for gas and solid phase.